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A BIT OF ENGINEERING AT MOUNT VERNON.

By M. L. WARD, Ottawa University.

THE mansion at Mount Vernon is about one-fourth of a mile from the Potomac river and about 150 feet above it. For about 400 yards from the river towards the mansion there is a wooded slope, crowned by a precipitous bluff from ten to fifteen feet in height. This bluff is about 100 yards from the mansion. This slope extending along the river is the deer park. In this park there have been many landslides, from time immemorial. Great masses of earth would become detached from the bank and slide down toward the river. This is shown by the uneven surface of the deer park. In 1903 occurred an immense landslide directly between the mansion and the river. Large masses of earth extending from the middle of the hillside even to the brow slipped down to the sea-wall which has been constructed to protect the bank from encroachments of the river. Repetitions of this slide would destroy a portion of the lawn and soon endanger the mansion. If possible they must be prevented. In May, 1903, the superintendent, Mr. H. H. Dodge, and the writer of this paper examined the locality, and we agreed that drainage only could solve the problem. Mr. J. A. Archer, a mining engineer, became interested in the matter, and I quote at length his account of work, which he kindly furnished me:

"An investigation of the serious condition at Mount Vernon, caused by landslides, was begun in May, 1903. These slides threatened the entire deer-park front, from the entrance gate to a point some 200 feet southwest of the old tomb, a total distance of about 800 feet. It was found that back from the Potomac river a distance of 300 feet, and 50 feet above the river level, a series of springs and marshy places occurred. One of these springs showed a daily flow of about 3000 gallons and another 2500 gallons. It was decided to make a series of borings to determine the general formation, with a view of establishing the levels of these different water veins. It was found that all the springs and 'weeps' came out on a bed of blue clay of twelve feet to fifteen feet in thickness, under which was another water-tight red clay of thirty feet in thickness; then five feet of sandstone to river level. Resting on this blue clay, fifty feet above river level, was a bed of water-bearing sand that showed varying thickness from five to fifteen feet. Through this evidently the water came, and when this sand was washed out the clay bed over it was let down, and a landslide was the result. Knowing now the levels of this blue clay, and finding only a five-degree dip to southwest, an attempt to find the general course of the underground water was made, and with success. A ridge north of Mount Vernon, known as the horseshoe ridge, was examined, and found to consist of Columbia river gravel, in which abundant water was found. This ridge is about four miles north of Mount Vernon. Standing on this we could look over the entire country towards Mount Vernon. A very distinct ridge was seen ending at Mount Vernon, forming one side of the frog of a horse's hoof. From the contour of the remainder of the country within the horseshoe, it was plainly evident that the Mount Vernon water must follow under this ridge. Outlet springs on the line were found all along the proper level lines. It was determined to run a tunnel under Mount Vernon at right angles to the general course of this central ridge, to cut the underground streams as nearly at right angles as possible.

"It was thought that possibly three tunnels would be necessary, and provisions were made for this. It may be added that wells on the estate were examined and the general water-level taken in these. Five feet was the general water-level. Depth of wells, seventy feet. Work was commenced on tunnel No. 1. Two feet of blue clay was carried in the heading at the start in order to take up the depressions in the clay which we of course expected and that were due to water wear. Running in on a grade of two inches to 100 feet for the first fifty feet, we experienced no difficulty, except great care was required to avoid runs of lower quicksands and falling of loose sands from above. At fifty feet we ran suddenly against a very hard sandstone, cemented sand and iron, five feet in thickness, with a footing on blue-clay level of one foot of pure white quicksand. In this sand cement we found numerous roots, some partly decayed, and some only the form of roots with the wood all gone, leaving simply a limonite shell. This material was singularly hard to break, and great care had to be exercised to prevent runs of quicksand underneath. The latter was stopped by the use of sand-bags and fine lawn grass. Hay or straw was of no use. We had now crossed at right angles several streams and had a flow of about 2000 gallons of water per day. After getting through this difficult piece of ground we suddenly came into a bank of solid sand, filled with water to the depth of five feet, and capped with two feet of putty clay that was well-nigh past picking or cutting out in any way. The water flow immediately picked up to 50,000 gallons per day, and held to this for a long period. We were draining out the entire basin under the hill, for such it proved to be. The springs commenced to fail, the wells to fall in their water-levels; the dam was broken.

"The putty clay in heading lasted for nearly 100 feet and was very hard to manage, a special tool being made to cut it—a compromise between a mattock and the chisel point of a pick. Picks only went into it and drew out their width in clay. Mattocks could not be driven in deep enough to avail anything. After passing through this material a solid sand bed was encountered that required very careful handling to prevent its falling away from the putty clay, which had risen beyond the roof. This condition lasted to the end, a distance of 279 feet. Careful record had been kept of channels and slight depressions in the blue-clay level as the tunnel was driven. Each depression was marked in the timber sets. At the end we found a depression of four feet and six inches, and concluded that it was best to stop at this point. The drain had affected the old-tomb spring, one of our guides, reducing it by one-third; still with the clay depression at the end of the tunnel it seemed to be safer and cheaper (due to long haul) to cut No. 2 tunnel to isolate old tomb. It was necessary now to take up the depressions indicated in tunnel No. 1. A ditch with a grade of two inches to the 100 feet was started under tunnel No. 1, to take up the lowest depression, four feet six inches at its head. This tunnel had been timbered with a view to this. The timbers had been set four feet apart at the bottom and two feet at the top, so that a stringer could be run from No. 1 timber on the bottom to No. 3 on each side of the tunnel, and a jack placed across No. 2 timbers. This was tightened up and No. 2 mudsill taken out, thus swinging No. 2 so that the ditch could be cut out between these sets. This ditch was cut and the depression thus all taken up. The deepest depression had clay cores rammed down on the outflow side of the tunnel. This ditch was then filled, first with three inches of clear gravel from the size of a walnut to the size of a pea, thoroughly rammed. On this were laid three two-inch tile-drain pipes in pyramid form. The entire ditch was then filled in with the same gravel. The flow of water was 10,500 gallons per day. The springs and weeps as far as old tomb were practically dry. The well at the house, 150 feet distant from the tunnel, was dry. The greenhouse well, 500 feet distant, was reduced by two feet. The old tomb spring was reduced one-third.

"Having now the exact conditions in the formation, and knowing the presence of the cemented dam around the hill, and its approximate width, we concluded to cut No. 2 tunnel to isolate the old tomb in blue clay, just carrying the sand level in the very top of the heading. The tunnel was driven in 125 feet. We encountered small streams of water as we went along, and broke through the limestone crust that lay between the blue clay and sand. Bore holes were made upward, so that we could feel our way across the iron dam. At 120 feet we commenced to get a good deal of water. All proper precautions were taken when we should break through under the dam. Sand-bags and grass were in readiness, and when, at 125 feet, we went into water-bearing sand, it was successfully held back and the water allowed to run out. The old-tomb spring stopped, and the tunnel was allowed to stand, except that a solid gravel filling was put in the heading in place of the grass and sand. This tunnel is to be filled with gravel, except near the mouth, where a cement wall, backed by a rammed blue-clay filling, is to be used as a dam, to back the water, to be carried off in pipes for further use. The water coming from the two tunnels is now concentrated into a cistern that had been constructed some years ago, and is forced into tanks by hydraulic rams, from which Mount Vernon gets its supply of water. The supply has been sufficient for all general use. The flow is 15,000 gallons per day now, from both tunnels. No diminution can be detected in the flow of the two tunnels. No sand is observed in catch-basins. Everything seems to come to rest.

"CONCLUSION.

"The problem is successfully solved. The whole hillside affected by the tunnels has dried out. No. 1 tunnel, left for observation, is to be filled with gravel, so that a channel will be left that will never close up. The theory regarding the dam formed around the brow of the hill may be of interest, and seems to have been borne out by facts. The iron in solution in the water was deposited probably in the form of pyrite by coming in contact with the tree roots. This was gradually changed to limonite. Old trees died out (last slide had two dead stumps of very old trees at its head), and gradually in wet seasons the water dissolved the iron, and a break in the dam occurred, and this caused a landslide.

"A quite interesting thing has been observed recently, pointing out to us how the waters in the upper levels to the north and west of us get down from the Columbia river level, fifty feet above the first sand level, to the lower sand level. In making the railroad cut just north of Mount Vernon a fault in the Columbian blue-clay base is shown for over 100 feet in length. The blue clay shows a continuous line for a long distance, but quite suddenly a fault is disclosed, the clay capping over a sand bed for some twenty feet; then a clear sand bed occurs for eighty feet. This would, of course, allow the water on the upper level to go through. As a matter of fact, this river-bed is now dry, whereas four miles back it carries the water."